UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
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MEMORANDUM

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To: Keith A. Takata, Director
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Subject: Five-Year Review of the Superfund Remedial Action at Iron Mountain Mine

Attached for your signature is the second Five-Year Review for the Iron Mountain Mine (IMM) Superfund site.

Over the past five years, the Agency has made substantial progress addressing the ongoing release of hazardous substances from IMM. Since its completion in the fall of 1994, the IMM treatment plant has reduced site copper discharges by 80 percent and site zinc and cadmium discharges by 90 percent, on average. The IMM treatment plant has treated more than 600,000 gallons of concentrated acid mine drainage from the underground mine workings at Iron Mountain, preventing the release of approximately 1,000,000 pounds of copper and 3,600,000 pounds of zinc. The High Density Sludge (HDS) modifications to the treatment plant, constructed by EPA in 1996, are performing better than expected, providing improved sludge management, increased landfill capacity, and reduced cost. In addition, other response actions implemented under the Superfund program have also reduced the amount and impact of releases from IMM.

We are currently designing the remedial action selected in September 1997 for the Slickrock Creek area source heavy metal discharges. Once implemented, this remedy should provide an overall reduction of 95 percent of the copper, cadmium and zinc discharges.

U.S. Environmental Protection Agency
Region 9
Superfund Division
Five-Year Review (Type Ia)
Iron Mountain Mine
Shasta County, California

I. Introduction

EPA Region 9 conducted this five-year review of the ongoing Iron Mountain Mine (IMM) Superfund remedial action in accordance with the requirements of CERCLA Section 121(c). This five-year review evaluates the protectiveness and functionality of each of the component remedial actions of the IMM remedial action that have been implemented to date.

EPA performed the first five-year review for the Site in September 1993, five years after the start of construction of the "partial cap". This was the first of several components of EPA's IMM remedial action that have been constructed and are currently in operation.

CERCLA Section 121(c) requires EPA to re-evaluate the protectiveness and functionality of the remedial action every five years after performance of the first five-year review for each site. Since the time of the performance of the first IMM five-year review, EPA has implemented numerous additional components of the IMM remedy. This five-year review addresses the partial cap, the Slickrock Creek diversion, the Upper Spring Creek Diversion, the Minnesota Flats lime neutralization ASM/HDS treatment plant and associated facitities, and the onsite mining waste disposal cell.

EPA is currently designing and constructing the remedial action selected in EPA's 1997 Record of Decision for the Site. EPA expects to complete construction of the Slickrock Creek "dam and treat" component of the IMM remedy in October, 2000. This five-year review does not evaluate the functionality and protectiveness of this component of the overall IMM remedy because it is not yet completed.

I.1 Authority Statement. Purpose. EPA Region 9 conducted this review pursuant to CERCLA Section 121(c), NCP Section 300.400(f)(4)(ii), and OSWER Directives 9355.7-02 (May 23, 1991), 9355.7-02A (August 25, 1994) and 9355.7-03A (December 21, 1995). It is a statutory review. The purpose of a five-year review is to ensure that a remedial action remains protective of public health and the environment and is functioning as designed. This document will become a part of the Site File. This review (Type Ia) is applicable to a site at which response is ongoing.

I.2 Site Characteristics. Iron Mountain is located in Shasta County, California, approximately 9 miles northwest of the City of Redding. The collection of mines on Iron Mountain is known as Iron Mountain Mine (IMM). They are the southernmost mines in the West Shasta Mining District and have been periodically worked for production of silver, gold, copper, zinc, and pyrite. The mine area includes extensive underground workings, side hill and open pit mining areas, waste rock dumps and tailings piles.

The rugged topography of the area is typical of a mountainous region with steep slopes bisected by streams. Elevations range from 600 feet on the Sacramento River several miles east of the mine property, to 3,800 feet on the top of Iron Mountain. The climate is characterized by warm dry summers and cool rainy winters.

Several, and possibly all, of the mines and the waste rock and tailings piles are discharging acidic waters, typically with a high content of heavy metals. These discharges are herein referred to collectively as acid mine drainage, or AMD. The largest sources of AMD are located within the Iron Mountain Mine property.

The largest source of heavy metal laden AMD is the Richmond Mine, and the second largest is the Hornet Mine, both of which drain into Boulder Creek. The third largest source, Old/No. 8 Mine Seep, drains into Slickrock Creek. These severe AMD discharges derive from hydrogeochemical reactions in the inactive underground mine workings and are the direct result of the mining activity that took place in these mineral deposits over many decades.

Emergency treatment of a portion of the AMD discharges from these three major sources was performed from 1988 to 1994. The emergency response actions significantly reduced the IMM heavy metal discharges during a severe long-term drought in Northern California. Under these drought conditions the Sacramento River ecosystem was at extreme risk to the large IMM heavy metal discharge. EPA’s emergency response action was successful in reducing, but not eliminating the impact of the IMM heavy metal discharges on the Sacramento River ecosystem.

Full-scale treatment of all of the AMD discharges from these three largest point sources at IMM began when the aerated simple mix (ASM) treatment plant began to operate in October 1994. The treatment plant was built at Minnesota Flats. During the period from October 1994 through December 1997 the ASM Minnesota Flats treatment plant (MFTP) reduced the overall Site discharge of copper by greater than 80 percent, and the overall Site discharges of zinc and cadmium by greater than 90 percent.

EPA modified the aerated simple mix treatment process to incorporate the High Density Sludge (HDS) process modifications to improve the cost-effectiveness of IMM treatment operations and to achieve technical improvements in the treatment plant and process operations and to increase the effective life of the Brick Flat Pit landfill. The HDS treatment plant has continued to effectively remove in excess of 80 percent of the copper and 90 percent of the zinc and cadmium loads from the overall IMM discharge. The HDS modifications have significantly reduced the cost and improved the reliability of IMM treatment operations. The effectiveness of IMM treatment plant operations is discussed in more detail in Attachment A.

The remaining IMM heavy metal discharges derive from widely dispersed area-wide sources. The discharges from these sources are closely associated with heavy rainfall and high runoff storm events. The IMM area source AMD discharges derive from waste piles, process tailings, sidecast spoils, ground disturbed by mining-related activities, discharges from buried workings or partially accessible workings, contaminated soil and debris, seeps, contaminated interflow and groundwater, and contaminated sediments in the Slickrock Creek, Boulder Creek, and Spring Creek watersheds at IMM.

In September 1997 EPA completed a remedial investigation and feasibility study (RI/FS) and signed a Record of Decision (ROD) selecting a “collection and treatment” remedy for the area source AMD discharges from the Slickrock Creek watershed at Iron Mountain. EPA ordered potentially responsible parties for the Site to perform the design and to construct the remedy. One PRP, Rhone-Poulenc, Inc. (Rhone-Poulenc), responded to the Order and is currently performing the design. Construction is expected to be completed by October 2000.

EPA continues to study and evaluate potential cleanup actions for the area source AMD discharges from the Boulder Creek watershed at IMM. EPA also continues to study and evaluate potential cleanup actions for contaminated sediments located downstream of the IMM discharges.

The fishery resources and other aquatic species in Keswick Reservoir and in the Sacramento River below Keswick Dam are the primary natural resources at risk to the continuing uncontrolled IMM heavy metal discharges. Both the exceedance of water quality standards and the accumulation of toxic sediments downstream of IMM contribute to the risks to species in the areas impacted by IMM releases.

I.3 Site Location. The Iron Mountain Mine Superfund site is defined pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) to include the inactive mines on Iron Mountain and areas where hazardous substances released from the mines are now located. The Iron Mountain Mine

(IMM) site includes approximately 4,400 acres of land that includes the mining property on Iron Mountain, several inactive underground mines, an open pit mine, areas that were mined by side hill mining activities, other areas disturbed by mining or mineral processing activities, numerous waste dumps, process tailings piles, abandoned mining facilities, mine drainage conveyance and treatment facilities, and the downstream reaches of Boulder Creek, Slickrock Creek, Spring Creek, Spring Creek Reservoir, Keswick Reservoir, and the Sacramento River affected by drainage from Iron Mountain Mine.

I.4 Summary of Site Investigations. Remedial Investigation (RI) activities at Iron Mountain began in September 1983, when Iron Mountain Mine was placed on the National Priorities List of the nation's most contaminated sites. These investigations continue to the present time.

I.4.1 1986 Record of Decision. EPA issued the first IMM Record of Decision (ROD) in 1986. The 1986 ROD was supported by an RI/FS report published in 1985 and an FS Addendum published in 1986. The 1985 RI report characterized the entire Iron Mountain Mine site with respect to the nature and extent of contamination. The FS and FS Addendum evaluated potential remedial alternatives for the IMM heavy metal discharges.

The 1986 ROD selected an interim remedy that identified a number of specific projects. These projects included the construction of a partial cap over the Richmond mineralized zone, including capping Brick Flat Pit (the open pit mine on top of Iron Mountain), and several subsidence areas; construction of a diversion of Slickrock Creek to avoid an AMD-generating mining waste slide; construction of a diversion of the Upper Spring Creek to avoid polluting its cleaner water and filling Spring Creek Reservoir; construction of a diversion of the South Fork of Spring Creek for a similar purpose; a study of the feasibility of filling mine passages with Low-Density Cellular Concrete; and an enlargement of Spring Creek Debris Dam, the exact size of which would be selected after a determination of the effectiveness of the other remedies.

I.4.2 1992 Record of Decision. Site characterization studies continued and focused on sources in the Boulder Creek watershed at IMM. EPA prepared the Boulder Creek Operable Unit RI/FS in 1992. The Boulder Creek OU RI/FS addresses remedial actions for (1) AMD discharges from the Richmond and Lawson portals, the two largest sources of acidity and metals contamination at IMM; and (2) the numerous waste rock piles, process tailing piles, seeps, and contaminated sediments that also affect contaminant levels in Boulder Creek. In conjunction with this RI/FS EPA updated its public health risk assessment for the site in 1991. In 1992 EPA prepared an Endangerment Assessment to characterize and evaluate the current and potential threats to the environment that may be posed by Iron Mountain Mine contaminants migrating to the groundwater, surface water, and air.

In September 1992, EPA signed its second Record of Decision for the IMM site. The 1992 ROD selected treatment of the AMD discharges from the Richmond and Lawson adits on an interim basis in a lime neutralization/sulfide High Density Sludge (HDS) treatment plant. EPA's 1992 ROD also selected the consolidation and capping of seven waste piles in a landfill to be located on the site. The 1992 ROD provided for disposal of the IMM treatment plant sludges in a landfill to be constructed in the inactive open pit mine, Brick Flat Pit, to meet regulatory requirements for this use.

I.4.3 1993 Record of Decision. Site characterization studies continued and focused on the AMD discharges from the underground workings associated with the Old/No. 8 Mine Seep in the Slickrock Creek watershed at IMM, the third largest source of contaminant discharges at IMM. EPA prepared an Old/No. 8 Mine Seep OU RI/FS report in 1993.

In September 1993, EPA signed the Record of Decision for the Old/No. 8 Mine Seep OU. In the 1993 ROD, EPA selected treatment of the AMD discharges from the Old/No. 8 Mine Seep on an interim basis at the IMM lime neutralization/HDS treatment plant, as appropriately modified.

I.4.4 1997 Record of Decision. EPA continued its site characterization studies focusing on the remaining AMD discharges that derive from widely dispersed area sources. The IMM area sources include waste piles, sidecast spoils, ground disturbed by mining-related activities, discharges from buried workings or partially accessible workings, contaminated soil and debris, seeps, contaminated interflow and groundwater, and contaminated sediments in the Slickrock Creek, Boulder Creek, and Spring Creek watersheds at IMM. The discharges from these sources are closely associated with heavy rainfall and high runoff storm events.

EPA initially concluded that it was technically impracticable to control, or collect and treat, the widespread area source AMD discharges. In 1994 EPA published the Water Management FS and proposed to select a water management remedial approach that relied upon the enlargement of the existing Spring Creek Debris Dam to control the release of these continuing heavy metal discharges into the Sacramento River system. EPA also proposed to perform treatment of Slickrock Creek base flows and investigate the feasibility of purchasing necessary dilution water flows. Based upon comments received during the public comment period, EPA reconsidered its proposed water management approach and concluded that it may be technically feasible to "collect and treat" at least a significant portion of the IMM area source AMD discharges.

EPA conducted further studies to evaluate the feasibility of "dam and treat" remedial alternatives and published the Boulder Creek Remedial Alternatives Study in 1995, and the Water Management FS Addendum in 1996. In EPA's May 1996 Proposed Plan EPA concluded that a "dam and treat" remedial approach would be technically practicable for the area source AMD discharges from the Slickrock Creek watershed at IMM. The collection and treatment of these discharges, in combination with other IMM remedial actions that were in place, would achieve an overall reduction of 95 percent in the Site discharges of copper, cadmium and zinc. This remedial approach is also potentially less costly than the remedy EPA proposed in 1994.

As a result of these studies, in September 1997 EPA signed a Record of Decision selecting the "dam and treat" alternative for collection and treatment of the area source AMD discharges from the Slickrock Creek drainage. The remedial alternative selected in the 1997 ROD includes the construction of a small dam in Slickrock Creek, clean water diversions, upgrades to the AMD conveyance pipeline, upgrades to the IMM lime neutralization/HDS treatment plant, and a short tunnel to discharge the high volumes of treated water to Spring Creek.

I.4.5 Ongoing RI/FS activities. EPA continues to perform studies regarding the area source AMD discharges from the Boulder Creek watershed at IMM and downstream sediments contaminated by the IMM heavy metal discharges. EPA expects to develop and evaluate remedial alternatives for these sources to support future decision making.

II. DISCUSSION OF REMEDIAL OBJECTIVES; STATUS OF THE REMEDIAL ACTION; AND AREAS OF NONCOMPLIANCE.

This section discusses the remedial action objectives, the status of the remedial action, and areas of non-compliance with Applicable, Relevant and Appropriate Requirements (ARARs).

II.1 REMEDIAL ACTION OBJECTIVES. The overall objective of EPA's IMM Superfund cleanup program is to eliminate the AMD discharges that are harmful to public health and the environment. EPA has identified three primary goals for the IMM Superfund remedial action:

- Comply with the water quality criteria established under the Clean Water Act and the California Porter-Cologne Water Quality Act. These standards were established to protect the valuable Sacramento fishery and aquatic ecosystem.

- Reduce the mass discharge of toxic heavy metals through application of appropriate control technologies.

- Minimize the need to rely on special releases of valuable water resources to dilute continuing IMM contaminant discharges in order to assure attainment of protective water quality criteria.

The contaminants of concern identified by EPA are acidity and toxic metals, which include copper, cadmium, and zinc. All of these are present in AMD discharges from the underground, sidehill and open pit mine workings and the area sources in the Slickrock Creek and Boulder Creek watersheds at IMM. EPA has concluded that a combination of source control, treatment, and water management alternatives are needed to assure an effective, implementable and cost-effective cleanup program for the IMM AMD discharges.

II.2 STATUS OF THE REMEDIAL ACTION. EPA, through fund lead and enforcement actions, has designed, constructed operated and maintained the remedial actions selected in the 1986, 1992 and 1993 Records of Decision for the IMM site. The actions selected in these three RODs are in operation and have effectively reduced the IMM discharges of copper by greater than 80 percent and zinc and cadmium by greater than 90 percent over the past four years. The Upper Spring Creek Diversion has effectively provided additional protection from spills of the continuing discharge of IMM contaminants into surface waters that are ultimately released from the Spring Creek Reservoir into the Sacramento River.

EPA, through an enforcement action, is currently designing and constructing the components of the remedial action selected in EPA’s 1997 ROD for the IMM site. Once this remedial action becomes operational in October 2000, the IMM heavy metal discharges (copper, cadmium and zinc) are expected to be reduced by approximately 95 percent overall.

II.2.1 1986 ROD. Initial Source Control and Water Management.

II.2.1.1 Access. During 1987 and 1988, EPA sought a court order to assure access to the site to construct the first IMM remedial action and to continue the remedial investigation. The court granted EPA access and ordered the property owner not to interfere with the remedial actions. Since that time, EPA has not encountered significant difficulty in obtaining access to perform studies or implement the remedial action.

Mr. Arman, President of Iron Mountain Mines, Inc. (IMMI), has recently notified EPA that IMMI intends to re-open the mine. To date, Mr. Arman has not submitted a work plan, schedule, or other submittal of any detail for EPA to review related his proposed mining venture. Mr. Arman has indicated that he will closely coordinate his efforts with EPA to assure that his actions would not interfere with EPA’s on-going cleanup.

II.2.1.2 Partial Cap. On July 19, 1988, EPA initiated construction of the partial cap in seven subsidence areas over the Richmond mineralized zone. EPA also capped the lower portion of Brick Flat Pit, the open pit mine on top of Iron Mountain. As part of that construction, EPA used tailings materials from the Minnesota Flat area, as well as select other tailings piles that contained relatively high concentrations of copper, cadmium, and zinc. EPA completed construction of the partial cap in July 1989.

II.2.1.2.1 Minnesota Flats Tailings Pile.

Effectiveness. The removal of the Minnesota Flats tailings pile has eliminated the IMM source that discharged heavy metals and acidity to Flat Creek. The removal of this source has substantially improved the water quality in Flat Creek. California Department of Fish and Game representatives have observed the return of some aquatic life to the lower reaches of this creek.

Remediation of the Stowell Mine, a small copper source upstream of IMM on upper Spring Creek (now diverted to Flat Creek), must be completed for further restoration of Flat Creek to occur. Mining Remedial Recovery Corporation (MRRC) is currently developing a proposal for cleanup of the Stowell Mine under order from the California Regional Water Quality Control Board.

Operations and Maintenance. No significant or special operations and maintenance efforts were required subsequent to completion of this remedial action in 1989.

Current Status of the Remedial Action. Monitoring of the water quality in Flat Creek is ongoing. The former site of the Minnesota Flats tailings pile is now the site of EPA’s lime neutralization ASM/HDS treatment plant. Portions of the former tailings pile site are now covered by plant facilities, parking lots and roadways. Other areas are now covered by sludge drying beds. These facilities, constructed pursuant to EPA’s 1992 ROD and 1993 ROD for IMM, further reduce the likelihood that any additional remedial action would be required in this area.

II.2.1.2.2 Brick Flat Pit Cap.

Effectiveness. The partial cap in Brick Flat Pit has performed precisely as intended, effectively shedding heavy surface water runoff from the intense winter storms and preventing infiltration of this water into the subsurface beneath the open pit.

Operations and Maintenance. No significant or special operations and maintenance efforts were required subsequent to completion of this remedial action in 1989. The Brick Flat Pit cap was properly engineered and constructed. The careful design and proper installation permitted EPA to incorporate the cap into the landfill liner system selected in EPA's 1992 ROD, discussed below.

Current Status of the Remedial Action. Monitoring of discharges from Brick Flat Pit is ongoing. Brick Flat Pit is now used as the landfill for treatment plant sludges. The membrane that was the original "cap" is now integrated into the "liner system" for the landfill. Under order from EPA, Rhone-Poulenc installed an additional liner and a filtrate collection system above the original cap to establish the landfill for the treatment plant sludges. The performance and maintenance of the landfill liner system is discussed below.

II.2.1.2.3 Subsidence Area Caps and Surface Water Controls.

Effectiveness. The "partial caps" in seven subsidence areas above the Richmond mineralized zone have performed as intended, effectively shedding intense winter storm surface water runoff in these localized areas preventing its rapid infiltration into the rubblized chimneys above collapsed stopes of the Richmond Mine. In addition to this direct infiltration, the rubbelized chimneys caused by mining might permit near surface lateral flow (or interflow) of water into the Richmond Mine.

The overall effectiveness of the caps in reducing the formation of AMD in the Richmond Mine cannot be estimated with certainty at this time. The caps were intended to reduce peak discharges. While peak discharges still occur, in the absence of the caps those discharges would likely be more pronounced or more severe.

Additional monitoring and analysis of the data is required before the effectiveness of the caps can be estimated. Although all parties agree that the approach may represent a promising and potentially cost-effective means of reducing remedial costs of treatment, the large annual variability of several other factors that affect the formation of AMD in the underground workings at IMM makes it difficult to assess the effectiveness of the partial caps and surface water controls.

In the 1992 Boulder Creek OU RI/FS, EPA considered significantly extending the partial caps to cover an area of approximately 30 acres, the "full cap". The full cap alternative was estimated to cost on the order of $30 million due to the difficulty of constructing a full cap in the steep mountainous terrain that includes the presence of landslides and subsidence zone related to the collapse of underground mine workings. EPA determined that although the full cap alternative might prove effective in reducing AMD formation in the Richmond Mine, it would not eliminate the need for a treatment plant at IMM. EPA determined that the cap would not be cost-effective in reducing treatment plant operation and maintenance costs.

Rhone-Poulenc representatives, outside of EPA's Superfund cleanup program, have independently designed and implemented several actions at IMM that are more limited in scope and are intended to increase the cost-effectiveness of the partial caps and surface water controls. The objective of Rhone-Poulenc's program is to reduce treatment plant operation and maintenance costs by implementing cost-effective measures that could reduce discharges from the mine portals. Rhone-Poulenc provided additional sealing of the subsidence area caps and developed a more extensive surface water drainage network than EPA implemented in its 1989 partial capping effort. However, since the time of Rhone-Poulenc's implementation of these additional measures, experience has shown that very large peak discharges still occur related to other pathways for water to enter the mine workings.

Operations and Maintenance. No significant or special operations and maintenance efforts were required subsequent to completion of this remedial action in 1989. The caps in the subsidence areas were properly engineered and constructed. The soil cover above the clay caps, the surface water ditches and other surface water controls require regular routine maintenance expected for this type of mountainous terrain that is exposed to regular intense winter storm conditions.

Current Status of the Remedial Action. Monitoring and routine operation and maintenance are ongoing.

II.2.1.3 Slickrock Creek Diversion. EPA, through an interagency agreement with the USBR, began construction of the Slickrock Creek diversion in July 1989 and completed construction in January 1990. The diversion consists of a small stilling pool and diversion dam, a 36-inch diameter urethane lined concrete pipeline approximately one mile in length and an energy dissipation structure to remove the kinetic energy of the diverted flows prior to their return to lower Slickrock Creek.

Effectiveness. The Slickrock Creek diversion has fully performed in accordance with its design. It effectively diverts clean water flows from the upper Slickrock Creek watershed around the contaminated reach of Slickrock Creek.

Several factors greatly complicate a detailed analysis of the effectiveness of this aspect of the response action, including the large annual variability of several other factors that affect the formation of AMD in the near surface sources and underground workings at IMM. At this time, the overall effectiveness of the Slickrock Creek Diversion in reducing the discharge of AMD from mineralization in the massive debris slide (or possibly through contact with underground workings in that area) cannot be estimated with certainty. However, the diversion is functioning properly and would be expected to reduce AMD production since less water is contacting the disturbed mineralization.

On occasion over the past eight yearss the trash rack protecting the diversion pipeline entrance has clogged with debris. Storms, less severe than the design storm, have caused the diversion structure to overtop. This overtopping has reduced the effectiveness of the diversion until such time that the trash rack could be cleaned. The initial trash rack was redesigned to reduce this problem, but the re-design has not been able to completely eliminate plugging with debris, particularly during extreme storm events.

Operations and Maintenance. No significant or special operations and maintenance efforts have been required related to the design or construction of this project component subsequent to completion of this remedial action in 1990. The diversion requires regular inspection and cleaning of the trash rack, particularly during intense storms which carry significant amounts of debris and litter.

- The Slickrock Creek Diversion suffered significant damage in the January 1995 storm as the result of impacts from a partially completed construction activity that Rhone-Poulenc performed independently of EPA's Superfund cleanup action at the Site. Portions of EPA's pipeline were exposed when Rhone-Poulenc diverted large surface water runoff flows from the upper watershed onto the roadway resulting in extensive erosion of the roadway and exposing the buried pipeline in several locations. The partial construction by Rhone-Poulenc also caused a major slope failure that put the pipeline in jeopardy of failure. EPA required Rhone-Poulenc to perform an emergency repair to remedy this problem.

- The trash rack, as re-designed by Rhone-Poulenc, continues to require routine inspection and maintenance, particularly during major storm events that can cause significant amounts of debris and litter to be washed into the stilling pool in front of the entrance to the diversion.

- The trashrack continues to plug with debris periodically, causing the Slickrock Creek flows to occasionally overtop the small diversion dam. These flows have on occasion eroded the riprap backfill. On these occasions, maintenance is required to repair the backfill.

- Otherwise, the required maintenance is typical for this application in mountainous terrain that is exposed to regular intense winter storm conditions.

Current Status of the Remedial Action. Surface water flow rate and water quality in Slickrock Creek above the influence of IMM are monitored as an ongoing activity. Periodic inspections of the physical condition of the diversion are conducted. Routine inspection and maintenance activities are ongoing.

II.2.1.4 Upper Spring Creek Diversion. Under EPA Order 90-08, ICI Americas, Inc. (ICIA), acting on behalf of Rhone-Poulenc, began construction of the Upper Spring Creek (USC) diversion in July 1990. The USC diversion was operational in January 1991. The Upper Spring Creek Diversion consists of a large grated drop inlet structure (that prevents large rocks and debris from entering the diversion while allowing the creek flows to drop into a rock trap and then into short tunnel), a 54-inch diameter urethane lined concrete pipeline several thousand feet in length, and an impact structure to dissipate the kinetic energy of the diverted flows prior to discharging them to Flat Creek.

Effectiveness. The Upper Spring Creek (USC) Diversion has fully performed in accordance with its design. It effectively diverts relatively clean water flows from the Upper Spring Creek to Flat Creek by-passing the Spring Creek Reservoir. The USC Diversion was designed to divert flows of up to 800 cubic feet per second (cfs), and experience over the past eight years indicates that its capacity is slightly higher.

This remedial action has proven to be a highly effective water management strategy. The USC Diversion diverts approximately 40 percent of the Spring Creek watershed surface water flows that historically have discharged into the Spring Creek Reservoir. This diversion has effectively created significant additional capacity to store runoff from the Spring Creek watershed that is highly contaminated by the IMM contaminant discharges.

Experience over the past eight years has shown this additional storage capacity to be important in both drought and wet weather conditions:

- During drought conditions, similar to those experienced during the late 1980’s and early 1990’s, the flows in the Sacramento River are regularly at minimum flow requirements and provide very little dilution of the concentrated IMM discharges. The additional storage capacity provided by the USC Diversion could provide the necessary storage in certain years, or delay a contaminant spill in other years, until Sacramento River flows could be increased (with adequate storage in Shasta Lake).

- During wet weather conditions, the additional storage could delay a contaminant spill until Sacramento River flows could be increased (with adequate storage in Shasta Lake).

Operations and Maintenance. The USC Diversion has performed effectively as designed to divert the USC flows and increase the protectiveness of Spring Creek Reservoir water management operations; however, several significant special operations and maintenance efforts have been required related to the inadequacy of the USC Diversion, as designed and constructed, to address high flows during intense storms at the diversion outlet to Flat Creek and in downstream areas. Special operation and maintenance efforts were required to provide improvements to address significant channel erosion at the outlet that undermined the impact structure, improvements to the property of owners downstream necessary due to the increased flows in Flat Creek, and replacement of the Flat Creek Bridge after its failure during the intense peak flows of the January 1997 storm.

- Rhone-Poulenc's design for channel improvements at the discharge point for the USC Diversion flows to Flat Creek was inadequate due to the weathered nature of the underlying rock in that area. Rhone-Poulenc was slow to provide an adequate design, despite EPA requirements to do so, over a period of several years. The intense peak flows experienced during the January 1995 storm significantly eroded the stream channel, creating deep pools and cascading falls just below the USC Diversion impact structure and outlet to Flat Creek. The severe erosion necessitated extensive repair action. Earlier action with a robust design approach would have prevented the need for these extensive repairs.

- Rhone-Poulenc designed stream embankment protection to protect the water supply intake of a riparian owner on Flat Creek. The design approach did not provide robust protection, causing the embankment protection to fail repeatedly over a period of several years. Rhone-Poulenc repaired the embankment protection repeatedly and eventually provided substantially increased embankment protection and an alternate water supply system.

- The Flat Creek Bridge failed during the January 1997 storm. Because of the importance of assuring site access for implementation of the IMM treatment remedy, EPA conducted a time-critical removal action to replace the 70-year old bridge. The replacement bridge is functioning properly.

- The diversion requires regular inspection and cleaning of the trash rack, particularly during intense storms which carry significant amounts of debris and litter. Routine maintenance is required to remove rock from the rock trap and to remove gravels from the impact structure.

- The diversion pipeline also requires regular inspection and maintenance. Recent inspections have identified certain areas where the urethane liner material is failing. Gravels that pass through the pipeline are beginning to erode the concrete pipe. Rhone-Poulenc has proposed to test certain repair procedures to assure long-term reliability and performance of this diversion.

Current Status of the Remedial Action. The water quality of Upper Spring Creek and Flat Creek are monitored as an ongoing activity. Periodic inspections of the physical condition of the diversion are conducted. Routine inspection and maintenance activities are ongoing.

II.2.1.5 South Fork of Spring Creek Diversion. Related to the increase in the cost of this component during design, in 1990 EPA deferred implementation of the South Fork of Spring Creek Diversion in order to allow for an additional evaluation of the cost-effectiveness of this water management approach relative increasing reservoir storage in the Spring Creek Reservoir. This portion of the response action is currently on hold pending implementation of other response actions, such as the remedy selected in the 1997 ROD.

II.2.1.6 Spring Creek Debris Dam Enlargement. EPA is not proposing to enlarge the Spring Creek Debris Dam at this time. In EPA's 1997 ROD for the IMM site, EPA determined that a "dam and treat" remedial approach is technically practicable for the Slickrock Creek area source AMD discharges and that similar controls are available for the discharges from the Boulder Creek watershed at IMM. EPA determined that the significant additional reduction in IMM heavy metal discharges, at potentially reduced cost from the proposed Spring Creek Debris Dam enlargement remedy, is preferable to water management alternatives.

II.2.2 1992 ROD. Boulder Creek Operable Unit.

II.2.2.1 AMD Treatment. EPA constructed the IMM Minnesota Flats lime neutralization ASM/HDS treatment plant through a combination of an enforcement action and fund-lead design and construction. Rhone-Poulenc began construction of the ASM components of the MFTP in the late summer of 1993 and completed construction in September 1994. Rhone-Poulenc also constructed the associated support facilities, including the AMD collection and conveyance system, the sludge drying beds, roadway improvements and the sludge landfill in Brick Flat Pit. EPA designed and constructed the HDS modifications to the MFTP. EPA constructed the HDS modifications from the spring of 1996 to January 1997. The MFTP currently consists of a lime feed system, AMD reactors, a lime contact tank, a thickener, aerators, supporting equipment and sludge dewatering drying beds.

Effectiveness. The MFTP has been very effective in reducing the IMM heavy metal discharge. The treatment process removes greater than 99.9 percent of all metals from the AMD flows that are delivered to the treatment plant for treatment. With the operation of the full scale IMM treatment plant since September 1994, the IMM copper discharge are reduced by greater than 80 percent and the zinc and cadmium discharges are reduced by greater than 90 percent from historic levels on an overall basis. During the period from 1994 through 1998 EPA's remedial action at IMM prevented the discharge of approximately 1,000,000 pounds of copper and approximately 3,600,000 pounds of zinc by treating approximately 600,000 gallons of concentrated acid mine drainage. (See Attachment A for further analysis.)

The HDS treatment plant modifications have been very effective in significantly reducing the costs of operating the IMM treatment remedy. The HDS modifications have reduced the costs associated with sludge hauling and landfill operations by reducing the volume of sludge produced to 42 percent of the sludge produced by the ASM process, and by lowering the unit price for hauling and placing the sludge in the landfill (to $14.60/cu.yd. from averages of $20/cu.yd. to $35/cu.yd. (wet weather haul) for the ASM sludges.

The HDS treatment plant will also increase the ability to store sludge AMD sludge on-site due to the increased density and improved handling characteristics of the HDS sludge relative to the ASM sludge. These factors should more than double the useful life of the Brick Flat Pit landfill.

The collection and conveyance system has in general operated effectively over this time period. Surges of AMD from the Richmond Mine have resulted spills to Boulder Creek for short periods during intense storms in 1995 and 1997. The collection system has been redesigned and reconstructed to prevent future spills. The AMD conveyance pipeline has performed as designed. A portion of the AMD conveyance pipeline is located in a landslide that moved during 1997. This section of the pipeline was modified to permit it to move with the landslide and the pipeline is being monitored to determine if further action will be required.

Operations and Maintenance. The MFTP began operation in September 1994 and has performed around-the-clock lime neutralization treatment operations through September 1998. The HDS process modifications came on line in January 1997. The operation of the IMM treatment plant is similar to operations of lime neutralization treatment plants throughout industry practice. The HDS modifications, in many ways, provide for more stable operations due to the large excess neutralizing capacity of the recirculated sludge particles. The intense nature of the winter storms at IMM presents the main challenge to ongoing operations.

Except for short down-time periods during heavy storm events, the plant has run continuously 24 hours per day, seven days per week. Upsets related to power failure, loss of the water supply and failure of the AMD collection system at the mine portals have prevented full treatment of all flows over the past four years of operation. Improvements implemented to these remedy components, as well as the construction of additional emergency and operating storage capacity, will improve this situation over the near-term.

Current Status of the Remedial Action. The treatment plant selected in the 1992 ROD is currently in full operation. SMC, on behalf of Rhone Poulenc, is currently operating the IMM lime neutralization HDS treatment plant pursuant to an EPA enforcement action. AMD discharges from the underground mine workings are being collected, conveyed and treated. The MFTP has the capacity to treat all AMD discharges conveyed to the plant for treatment.

On an ongoing basis, EPA monitors several aspects of treatment plant operation, including process parameters and influent and effluent flow rate and water quality. EPA also conducts periodic inspections of the physical condition of the treatment plant. Routine maintenance activities are ongoing.

I.2.2.2 Storage of Treatment Sludge At Brick Flat Pit Landfill
Pursuant to the 1992 ROD and 1993 ROD, EPA required the construction of a landfill at Brick Flat Pit for storage of treatment plant sludges. Constructed at the bottom of the open pit mine at Brick Flat Pit, the landfill has a double liner and filtrate collection and monitoring system. Rhone-Poulenc, in response to an EPA order, constructed the landfill. The first sludges were placed in the landfill in 1994.

Effectiveness The Brick Flat Pit landfill has been very effective in storing the sludges from the MFPT. Rhone-Poulenc deposited three years of ASM operations and the landfill has effectively contained the difficult to handle ASM sludges. In 1997, the HDS plant came on line, and the HDS sludges are currently being placed into the landfill. The high quality of the HDS sludge permits the landfill to be managed as a dry landfill, with the sludges being placed and compacted to maximize landfill capacity. Brick Flat Pit will provide a long-term stable disposal cell for these sludges.

Operations and Maintenance The ASM sludges have been deposited and contained in Brick Flat Pit, but the difficult handling characteristics of the ASM sludges have created several operational and maintenance difficulties over the past several years. Among other things, the only means available to deposit the sludge into the landfill involved dumping the sludge from one of three dump stations. Due to improper design by Rhone-Poulenc, each of these stations failed in use. The most significant dump station failure occurred when Rhone-Poulenc used the west end of the landfill and dumped the sludges directly onto the liner system. These practices resulted in an extensive failure in the west end liner system, requiring expensive repairs. In addition to the liner failure, the dumping of these materials caused failure of the filtrate collection system and resulted in the release of sludges to Slickrock Creek. This event required an emergency response during a winter storm to correct the problem.

The HDS treatment plant sludges have superior handling characteristics that solve the problems presented by the ASM sludges. We are currently placing and compacting these materials into the landfill, which permits the landfill to be managed as an engineered landfill. As discussed above, the improved handling characteristics and greater density provide cost savings and will extend the useful life of the landfill.

Current Status of Remediation The west end liner system is being repaired, and we expect that the system will be fully repaired before the upcoming wet season. The HDS sludges are currently being placed in the pit. The agency is monitoring the water quality exiting the pit on a routine basis. Future operations anticipate annual placement of well-dried HDS sludges as an engineered fill, consistent with a long-term sludge management plan for the landfill.

I.2.2.3 Consolidate and Cap Seven Waste Piles. Under order from EPA, Rhone-Poulenc excavated, consolidated and capped seven largely pyritic waste piles in a disposal cell located on site at IMM. The landfill was designed to comply with California mining waste requirements.

Effectiveness. The removal and disposal of the seven mining waste piles has been effective in eliminating these sources of heavy metal discharges to Boulder Creek. It is difficult to quantify the effectiveness of this remedial action in reducing the overall Boulder Creek area source heavy metal discharge load. EPA expects to continue to see improvement over the next several years. EPA continues to monitor the water quality in Boulder Creek for this purpose and to gauge the need for further action.

Operations and Maintenance. No significant or special operations and maintenance efforts were required subsequent to completion of this remedial action in 1994. The wet winter storms of 1998 caused a major movement of a landslide. The mining waste disposal cell is located on the edge of this landslide but does not appear to have been affected by the 1998 movement. The integrity of the disposal cell will be monitored over time related to this issue.

Current Status of the Remedial Action. Monitoring of the water quality in Boulder Creek is ongoing. Landslide movement is monitored. The disposal cell is routinely inspected. Maintenance will be provided as required.

II.2.3 1993 ROD. Old/No. 8 Mine Seep Operable Unit.

II.2.3.1 AMD Treatment. In the 1993 ROD, EPA selected treatment of the AMD discharges from the Old/No. 8 Mine Seep on an interim basis at the IMM lime neutralization HDS treatment plant, as appropriately modified. Under Order from EPA, Rhone Poulenc designed and constructed the facilities to collect and convey to the MFTP for treatment. Rhone-Poulenc also constructed the ASM components of the IMM lime neutralization treatment plant. EPA constructed the HDS modifications to the treatment plant.

Effectiveness. As discussed above with respect to EPA's 1992 ROD for the Boulder Creek OU (II.2.2), the MFTP has been very effective in reducing the IMM heavy metal discharge. See section II.2.2.1 above and Attachment A and for further analysis of the effectiveness of the treatment of these flows.

Operations and Maintenance. See section II.2.2.1 above and Attachment A and for further analysis of the operations and maintenance of the treatment of these flows.

Current Status of the Remedial Action. The remedy selected in ROD3 is currently in full operation. SMC, on behalf of Rhone Poulenc, is currently operating the IMM lime neutralization HDS treatment plant pursuant to an EPA enforcement action. AMD discharges from the underground mine workings are being collected, conveyed and treated. The MFTP has the capacity to treat all AMD discharges conveyed to the plant for treatment.

Influent and effluent flow rate and water quality are monitored as an ongoing activity. Process parameters are monitored as an ongoing activity. Periodic inspections of the physical condition of the treatment plant are conducted. Routine maintenance activities are ongoing.

II.2.4 1997 ROD. Slickrock Creek Area Source AMD Discharges.

II.2.4.1 Dam and Treat. The Slickrock Creek "dam and treat" remedy is currently being designed. Construction of the upgrades to the AMD conveyance pipeline has commenced. Construction is expected to be completed by October 2000.

II.3 AREAS OF NON-COMPLIANCE. The IMM remedial actions selected and implemented to date constitute an interim remedial action and do not address all of the AMD discharges from the Site.

II.3.1 Slickrock Creek Area Sources. The largest remaining uncontrolled heavy metal discharge is from the area source AMD discharges in the Slickrock Creek watershed. EPA expects to begin collection and treatment of the Slickrock Creek area source discharges in October 2000.

II.3.2 Boulder Creek Area Sources. EPA continues to study the most appropriate means of responding to the discharges from the area sources in the Boulder Creek watershed. These discharges constitute approximately one-third of the remaining uncontrolled copper discharge and one-half of the remaining zinc discharge from IMM.

II.3.3 Sediments. EPA is currently studying the contaminated sediments down gradient from IMM now located in Spring Creek, Spring Creek Reservoir, Keswick Reservoir, the Sacramento River; Flat Creek and other areas. It is clear that these contaminated sediments pose a threat to the environment. These contaminated areas are devoid of benthic communities or the benthic communities are severely impaired. Additionally the fine grained sediments located in the Spring Creek arm of Keswick Reservoir could become entrained in flood waters, spills from the Spring Creek Debris Dam, or power plant discharges. The release of these sediments may pose a threat to the valuable salmon spawning grounds of the upper Sacramento River.

II.4 USBR CVP OPERATIONS. The IMM interim remedy continues to rely on USBR water management actions, on an interim basis and in accordance with the 1980 MOU, to provide for the safe release of the continuing IMM contaminant discharges from the Spring Creek Reservoir (to the extent technically feasible without implementation of further response actions at IMM).

The interim water management actions are necessary to reduce the likelihood of uncontrolled spills and meet the State Basin Plan Standards for water quality. Significant further remediation of the IMM area source discharges is required to ensure that USBR operations of SCDD would be able to safely release any continuing uncontrolled IMM discharges.

IMM Heavy Metal Loads. Under current conditions with treatment of the major IMM heavy metal sources, the storm inflows to the Spring Creek Reservoir are highly contaminated

Hydrologic Factors. Storms that cause these contaminated waters to fill the Spring Creek Reservoir within a few days will likely occur every 5 to 10 years.

III. RECOMMENDATIONS.

1. Coordinate closely with Mr. T. W. Arman and Iron Mountain Mines, Inc. to assure that any proposed mining venture would not hinder EPA access to operate and maintain the remedial actions at IMM, nor otherwise interfere with the effectiveness of the remedy.

2. Continue to perform inspections and monitor the condition of the USC Diversion and the SRC Diversion. Perform maintenance when required.

3. Continue to perform inspections and monitor the condition of roadways, capped areas, mining waste disposal cells, the Brick Flat Pit sludge landfill, and surface water controls. Provide maintenance or upgrade as required.

4. Assure completion of all necessary upgrades to the AMD collection and conveyance system to assure collection and conveyance of all of these concentrated AMD discharges to MFTP for treatment. Provide maintenance or additional upgrades as required.

5. Assure the reliability and redundancy of critical treatment plant systems, including the water supply, electrical, dry lime storage and feed, lime slurry, reactor mixing, and aeration.

6. Assure the construction of adequate emergency and operating storage capacity to assure full treatment of all AMD discharges collected and conveyed to the MFTP for treatment.

7. Evaluate promising technologies that could prevent or reduce AMD production in a cost effective manner.

IV. Statement on Protectiveness.

The Iron Mountain Mine Superfund remedy is not at this time fully protective of human health and the environment. EPA has made substantial progress and the remedial actions implemented to date have afforded substantial protection to the valuable Sacramento River ecosystem and water supply.

EPA is currently in the process of designing and constructing the remedial action selected in the 1997 Record of Decision for the Iron Mountain Mine site. When implemented, this remedy will provide substantial additional protection to the Sacramento River ecosystem and water supply.

EPA also continues to conduct an RI/FS to address the area source AMD discharges from the Boulder Creek watershed at IMM and the contaminated sediments down gradient from IMM. EPA expects to develop and evaluate potential remedial actions to address these areas for future decision making.

V. Next Five-Year Review.

The next five-year review of the Iron Mountain Mine Superfund remedial action will be conducted by EPA on or before September 30, 2003.

Keith A. Takata

Keith A. Takata, Director
Superfund Division, Region 9

ATTACHMENT A

IRON MOUNTAIN MINE

SITE EVALUATION

CH2M HILL, INC.

Site Evaluation
Iron Mountain Mine

PREPARED FOR: Rick Sugarek/EPA

PREPARED BY: John Spitzley/CH2M HILL

EPA WORK ASSIGNMENT: 025-w6-0036

DATE: September 25, 1998

Introduction

This technical memorandum evaluates the effectiveness of remedial actions in reducing copper and zinc discharges from the Iron Mountain Mine (IMM) site during the last 5 years. Effectiveness is evaluated on the basis of the observed reduction in the copper and zinc discharges from Spring Creek Debris Dam (SCDD) located downstream from the IMM site.

This technical memorandum also evaluates the high density sludge (HDS) treatment process used to neutralize and remove contaminants from acid mine drainage (AMD) at the IMM site.

Background

Iron Mountain is located approximately 9 miles northwest of Redding, California. The mountain is bordered to the south/southwest by Slickrock Creek and to the north/northwest by Boulder Creek, as shown on Figure 1. AMD from abandoned mine workings, waste piles, and other area sources discharge and contaminate Boulder and Slickrock creeks. These creeks flow into Spring Creek, which subsequently flows into Spring Creek Reservoir, Keswick Reservoir, and the Sacramento River.

The U.S. Bureau of Reclamation (USBR) constructed the SCDD, which dams the Spring Creek Reservoir, in the early 1960s to meter the contaminated discharge from Spring Creek into Keswick Reservoir and the Sacramento River. The USBR monitors the daily flow from SCDD and routinely completes analytical testing on the discharge waters to determine the metal concentrations of copper and zinc.

Remedial Actions

The U.S. Environmental Protection Agency (EPA) has selected and implemented several major remedial actions at the IMM site. During the period from 1985 through 1990, EPA evaluated, designed, and constructed the following remedial actions selected in the first Record of Decision for the IMM site (ROD1):

- Clean water diversions to route clean water around contaminated waste areas
- Tailings and waste pile removal
- Capping of an open-pit mine and subsidence areas to halt rainwater infiltration into the mine workings

Prior to implementation of these actions, site discharges of copper had been partially remedied by treating portal discharges in Slickrock and Boulder creeks using a copper cementation process. The process involves running AMD discharges through tanks containing shredded tin cans. The AMD copper replaces the iron exposed in the tin cans. Cementation plants have been operated intermittently at Iron Mountain since the 1920s.

In 1989 EPA constructed a 60-gallon-per-minute (gpm) emergency treatment plant to treat a portion of the winter discharges from the Richmond portal. The plant was upgraded to treat a maximum of 140 gpm and operated during the winter months during water years 1992 through 1994. The emergency treatment plant was in operation for the following periods:

- December 1989 to March 1990
- November 1990 to April 1991
- December 1991 to May 1992
- November 1992 to May 1993
- December 1993 to September 1994

In 1992 EPA selected the construction of an HDS treatment plant and ancillary facilities to collect and treat all discharges from the Richmond and Lawson portals (ROD 2). In 1993 EPA selected the collection and treatment of AMD discharges from the Old/No. 8 Mine Seep (ROD 3).

Effectiveness of Remedial Actions

Site Discharges of Copper and Zinc

Contaminant discharges from Boulder and Slickrock creeks discharge through SCDD into Keswick Reservoir, as depicted in Figure 1. The USBR computes the average daily discharge from SCDD using the SCDD outlet gate settings. Flows measured using the outlet gate discharge curves have been favorably compared to flows estimated using the standard broad-crested weir located just downstream of the outlet gates.

The USBR routinely completes analytical laboratory testing on samples collected just downstream from the outlet gates at SCDD. During the period 1983 through 1994, the State of California Regional Water Quality Control Board routinely collected samples at SCDD, Keswick Dam, and Iron Mountain. Analytical testing was performed on the SCDD samples to obtain pH, total copper, total zinc, and total cadmium. At SCDD, it was determined that the pH was sufficiently low that, for most samples, the dissolved and total concentrations for each of the metals were approximately equal. The pH of the water retained in Spring Creek Reservoir typically ranged from pH 2 to pH 3, with an average pH value of 2.8 computed for the 264 samples collected during this period.

Since 1994, one of the results of the remedial actions has been a general increase in the pH of water in Spring Creek Reservoir. During the period from November 1996 through May 1998, EPA conducted winter sampling and analytical testing on samples discharged from SCDD. The pH of the water ranged from 3.75 to 5.2, with an average pH value of 4.5 computed for the 46 samples collected during this period.

The USBR typically samples SCDD discharges on a weekly or biweekly basis, and more often during high flow conditions or when the reservoir is within 75 percent of reservoir capacity. The historical concentrations fluctuate as a function of inflow and treatment at the site. For the purpose of the calculations presented in this technical memorandum, daily copper and zinc concentrations were calculated assuming a linear variation between the actual reported values.

SCDD Discharge Loads

Average daily copper and zinc discharge loads from SCDD were calculated using the computed concentrations and the USBR average daily discharges for the period October 1, 1969 through September 1998. The annual and cumulative copper and zinc discharges for the period are presented in Figures 2 and 3, respectively. Appendix Tables A-1, A-2, and A-3 list the data sets illustrated in Figures 2 and 3. For this period, approximately 5 million pounds of copper and 22.5 million pounds of zinc were discharged from SCDD into Keswick Reservoir and the Sacramento River.

Table 1 lists the copper and zinc loads (in pounds) discharged from SCDD for water years 1994 through 1998. (The water year extends from October 1 of the year proceeding the water year through September 30 of the water year.) For this period approximately 217,400 pounds of copper and more than 400,000 of zinc were discharged from SCDD into Keswick Reservoir and the Sacramento River.

TABLE 1
Copper and Zinc Discharge from Spring Creek Debris Dam
Water Years 1994 through 1998

Water Year	SCDD Discharge (acre-ft)	Annual Copper (lb)	Annual Zinc (lb)
1994	4,200	32,700	118,700
1995	41,000	72,600	110,400
1996	18,700	28,200	52,600
1997	28,900	27,900	47,300
1998	75,000	56,000	78,700
Total	**167,800**	**217,400**	**407,600**

IMM Treatment Plant Operation

AMD discharges from Iron Mountain have been collected and treated during the period December 1989 through September 1998; first, an emergency response action (1989 – 1994) and subsequently full scale treatment operations (1994 – 1998). Copper and zinc loads, removed by treatment, were calculated using daily flow and metal concentration data provided by Stauffer Management Company (SMC).

The Minnesota Flats Treatment Plant (MFTP) began operation in September 1994 and has continued round-the-clock operations through September 1998. Except for short down-time periods during heavy storm events, the plant has run continuously 24 hours per day, 7 days per week for the period. SMC reports daily inflow and metal concentrations that may be used to compute the total copper and zinc loads collected for treatment. Comparison of influent and effluent data shows that the treatment process is greater than 99.9 percent effective in removing dissolved metals from the AMD.

Figures 2 and 3 show the copper and zinc loads removed by the emergency treatment plant and the MFTP for water years 1989 through 1998. For this period approximately 1.16 million pounds of copper and 3.92 million pounds of zinc have been removed by the IMM treatment plants.

Table 2 lists the copper and zinc loads collected from AMD discharges at the IMM treatment plants for water years 1994 through 1998. For this period the IMM treatment plants have treated nearly 600,000 gallons of AMD, and removed over 1 million pounds of copper and over 3.2 million pounds of zinc from the discharges into Spring Creek, Keswick Reservoir, and the Sacramento River.

TABLE 2
Copper and Zinc Discharges Collected by Iron Mountain Mine Treatment Plants
Water Years 1994 through 1998

Water Year	Plant Inflow (gal)	Influent Copper (lb)	Influent Zinc (lb)
1994	22,100,000	36,000	227,000
1995	162,370,000	351,000	973,000
1996	108,880,000	207,000	586,000
1997	107,150,000	170,000	538,000
1998	192,780,000	264,000	917,000
Total	**593,290,000**	**1,028,000**	**3,241,000**

Total Copper and Zinc Loads Discharged from IMM

Table 3 lists the total copper and zinc loads discharged from IMM for water years 1994 through 1998. The total load includes portal flows (now collected for treatment) and the SCDD discharge loads. For this period IMM discharged more than 1.2 million pounds of copper and 3.6 million pounds of zinc.

Table 3 also shows the percent reduction in copper and zinc discharges from IMM for the period as a result of EPA’s treatment remedial action. The percent reduction is calculated as the load removed by treatment divided by the total load (the sum of the load removed by treatment and the load discharged from SCDD). These calculated values do not take into account the reduction in copper and zinc contaminant loads as a result of other remedial actions, including the construction of the Slickrock Creek clean water diversion, capping of BFP and subsidence areas, and removal of sulfide tailings and waste piles in Boulder Creek. For this 5-year period, collection and treatment of portal discharges have resulted in an average reduction in copper discharges of 83 percent and an average reduction in zinc discharges of 89 percent.

TABLE 3
Total Iron Mountain Copper and Zinc Discharges and Reduction in Site Discharge
Water Years 1994 through 1998

Water Year	SCDD Discharge (acre-ft)	Total IMM Copper (lb)	Total IMM Zinc (lb)	Discharge Reduction Copper (%)	Discharge Reduction Zinc (%)
1994	4,000	69,000	346,000	53	66
1995	40,000	424,000	1,083,000	83	90
1996	20,000	235,000	638,000	88	92
1997	30,000	197,000	585,000	86	92
1998	70,000	320,000	996,000	83	92
Total	**170,000**	**1,246,000**	**3,648,000**	**83**	**89**

HDS Treatment Plant Evaluation

Treatment Plan Construction

ASM: In response to EPA Administrative Orders 93-01 and 94-12, SMC designed and constructed an aerated simple mix (ASM) treatment plant at IMM. The MFTP began operation in September 1994, treating discharges from the Richmond and Lawson portals. Flows from the Old/ No. 8 Mine Seep were added to influent flows at the MFTP in October 1994. The effectiveness of metal removal of ASM treatment is reflected in the 1995 and 1996 water year results, listed in Table 3.

HDS: Because of excessive sludge volumes and poor handling characteristics of the ASM sludge, EPA constructed the HDS treatment plant at the MFTP, with startup in January 1997. The HDS treatment process was selected by EPA to improve the cost effectiveness of IMM treatment operations and to achieve the improvements in plant and process operations discussed in the following sections.

1. **Decrease the amount of sludge generated by the ASM treatment process.** The ASM sludge retained a high percentage of water. SMC submitted data showing that the 200,000 cubic yards of sludge generated using SMC's ASM process from September 1994 through November 1996 contained an average 62 percent water at the time the sludge was hauled from MFTP to Brick Flat Pit (BFP). During the wet-winter hauls conducted by SMC in 1995 and 1996, the ASM sludge contained an average 65 percent water.

   EPA laboratory testing and analyses projected that the HDS sludge would be discharged into the sludge drying beds at 35 to 40 percent solids (60 to 65 percent water). EPA analysis predicted that the HDS sludge would drain to a minimum 50 to 70 percent solids (30 to 50 percent water) before the sludge was excavated and transported to the BFP facility (EPA, 1996). EPA predicted that the decrease in sludge volume would negate the need for further expensive wet-winter sludge hauls, as completed by SMC in 1995 and again in 1996.

2. **Improve process performance of the sludge drying beds.** SMC constructed three sludge drying beds in 1994 for dewatering and temporary storage of the ASM sludge at

the MFTP site. An additional drying bed was constructed in 1995. ASM process operations demonstrated that the ASM sludge discharged to the sludge drying beds clogged the sand drainage layer and retarded drainage, which resulted in the sludge drying beds not draining and actually operating as wet ponds. EPA analyses projected that the granular nature of the HDS sludge would provide superior permeability and drainage, and extend the operational cycle time of the sludge beds by reducing sludge volume and effectively increasing storage duration.

3. **Improve sludge handling characteristics.** Because of the ASM sludge high percentage of water, the sludge was found to be relatively difficult to handle. Excavation of the ASM sludge from the sludge drying beds during the wet-winter hauls was complicated because the sludge was easily fluidized during the excavations. The sludge lost all shear strength and flowed like a liquid. Because of this, the excavator equipment operators could not recognize the location of the bottom of the sludge/top of sand drainage layer. The ASM sludge excavations resulted in destruction of the protective geogrid geosynthetic marker layer and penetrations through the underlying geotextile overlaying and protecting the filtrate collection system. EPA projected that, with its superior characteristics, HDS sludge would require less volume than ASM sludge, negate the need for wet-winter hauls, permit the sludge the benefit of a full summer for drying, and allow optimal excavation of the sludge in dry field conditions.

4. **Permit the operation of BFP as an engineered landfill.** SMC found that the ASM sludge was highly “sensitive” or “quick,” and experienced a loss of strength with applied shear stresses or vibration. The ASM sludge arriving at BFP appeared as a flowable liquid. The sludge was discharged from dump sites constructed at the rim of the northeast corner of the pit in 1995 and a dump site on the west end of the pit in 1996. Both of these dump locations failed, resulting in significant damage to the filtrate collection risers and to the geotextile lining system separating the stored sludge from sulfides and acid seeps. EPA projected that the superior mechanical characteristics of the HDS sludge would enable the HDS sludge to be compacted using conventional earth-moving equipment and placed in BFP in a controlled, engineered manner.

Treatment Plant Operations

The HDS treatment plant began startup operations on January 7,1997. All AMD inflows to the MFTP have been treated using the HDS process since that date. In response to EPA order, SMC has monitored daily inflow and effluent discharge, recording daily flow volume, copper, zinc and lead concentrations, lime demand, and solids formed.

EPA conducted an evaluation of the available SMC ASM sludge data obtained for the period January 1995 through November 1996 (EPA, 1996). Geotechnical data included percent solids and bulk density. Percent solids is equal to the weight of the solids divided by the sum of the weight of the solids plus the weight of the water. Bulk density is equal to the total weight (water plus solids) per unit volume. The dry density is equal to the weight of the solids per unit volume and may be computed by multiplying the percent solids times the bulk density. Dry density is a measure of the solids content of the sludge. The values for these parameters are presented in Table 4. This data shows that average percent solids for the sludge hauled by SMC in 1995 and 1996 contained about 38.4 percent solids or 61.6 percent water. The sludge had an average dry density of approximately 33.0 pounds per cubic foot.

Table 4 also shows average values for sludge hauled in January, February, and March 1995 and 1996. These data are of interest because reliance on wet-winter haulage during these months results in poorer performance of the sludge drying beds, less sludge dewatering, and greater volumes of wet sludge to be excavated and hauled.

The data show that, on average, the January through March sludge hauled by SMC contained approximately 33.9 percent solids, or 66.1 percent water. The analyses show that the sludge had an average dry density of approximately 28.3 pounds per cubic foot.

TABLE 4
Results of ASM Sludge Testing
January 1995 through November 1996

Pond No.	No. Samples	Haulage Date	Percent Solids (%)	Bulk Density (pcf)	Dry Density pcf)
4	8	Jan-95	34.2	81.5	27.9
2	6	Feb-95	30.3	82.2	24.9
1	6	Feb-95	29.9	81.1	24.2
4	6	Mar-95	36.4	85.0	30.9
2	6	Mar-95	34.9	84.3	29.4
1	6	Apr-95	35.3	83.0	29.3
4	6	May-95	42.4	88.1	37.3
2	6	Oct-95	44.1	91.1	40.2
1	6	Oct-95	45.4	90.8	41.2
4	6	Mar-96	37.7	85.6	32.3
1	6	Apr-96	40.5	88.0	35.6
2	6	Oct-96	45.5	86.9	39.6
1	6	Nov-96	42.8	85.7	36.7
Avg(1)	**80**	**95-96**	**38.4**	**85.6**	**33.0**
Avg(2)	**38**	**95-96**	**33.9**	**83.3**	**28.3**

Notes: Avg (1) = Average for all samples.
Avg (2) = Average for January, February, and March 1995 and 1996 samples.
pcf = pounds per cubic foot.

The 1998 El Nino storms tested the capacity of the HDS treatment process to treat elevated peak AMD inflows at influent rates exceeding the design flow. While the peak design flow rate for the HDS treatment plant was equal to approximately 1400 gpm, the average daily AMD influent flow rate in 1998 exceeded 1000 gpm on 21 days and exceeded 2000 gpm on three days. Table 5 summarizes the sludge discharge schedule reported by SMC for 1998.

Table 5 shows the start date and end date for sludge wasting to each of the drying beds, the volume of AMD that was treated during the wasting period, and the sludge volumes in each bed as surveyed by Pace Engineering for SMC on August 28, 1998. Approximately 5,000 cubic yards of ASM sludge was retained in Drying Bed 1 from the 1997 winter season.

TABLE 5
Sludge Discharge Schedule
1998 Winter Season

Drying Bed	Start Date	Stop Date	Treatment Process	Volume AMD (gal)	Volume Sludge (cubic yds)
1	01/01/97	01/05/97	ASM	8,210,500	5,080
1	08/01/97	02/10/98	HDS	59,055,350	13,170
4	02/10/98	03/21/98	HDS	51,641,018	16,262
2	03/21/98	07/24/98	HDS	75,344,698	18,092
3	07/24/98	Present	HDS	14,995,673	

EPA sampled sludge drying beds 1, 2, and 4 on August 27, 1998. SMC plans to begin the 1998 sludge haul the week of September 28, 1998. Six sludge samples were obtained from each of the sludge drying beds at depths of 2 and 4 feet. Samples were tested for percent solids, bulk density, and dry density. Results of the analyses are presented in Table 6. These data show that 18 HDS sludge samples averaged 68.2 percent solids, or 31.8 percent water. The bulk density for the 18 samples averaged 101 pounds per cubic foot and the dry density averaged 68.9 pounds per cubic foot.

TABLE 6
Results of HDS Sludge Testing
August 1998

Pond No.	No. Samples	Haulage Date	Percent Solids (%)	Bulk Density (pcf)	Dry Density (pcf)
1	6	Sep-98	64.1	96.7	62.0
2	6	Sep-98	68.8	105.5	72.5
4	6	Sep-98	71.5	100.9	72.1
Average	**18**	**Sep-98**	**68.2**	**101.0**	**68.9**

Comparison of the ASM data presented in Table 4 and the HDS data presented in Table 6 shows that the HDS sludge has an average dry density more than twice that of the ASM sludge hauled in 1995 and 1996. This means that the HDS sludge occupies a volume less than one-half that of the ASM sludge. The data also show that the HDS sludge has an average dry density more than 244 percent of that of the average dry density of the ASM sludge hauled in January through March 1995 and 1996. This means that the HDS sludge occupies a volume about 41 percent of the ASM sludge hauled in January through March of 1995 and 1996.

The benefits of the HDS process can be evaluated by computing the amount of ASM sludge that would have been generated if the HDS treatment plant had not been in operation in 1998. The dry density data show that the ASM sludge occupies a volume of between 209 and 244 percent of that of the HDS sludge. Table 7 lists the predicted ASM sludge volumes that would have been produced in 1998 if the ASM treatment process had continued in operation. These data show that the ASM treatment process would have generated an additional 51,600 to 68,300 cubic yards of ASM sludge during the period August 1997 though July 1998. Because the 4 sludge drying beds have a maximum capacity of approximately 70,000 cubic yards, these data show that a wet-winter sludge haul would have been required in March 1998 using the ASM treatment process.

Data submitted by SMC indicate that a sludge haul conducted in March 1998 would likely have been conducted in the rain. A total of 12.79 inches of rainfall was reported by SMC for the MFTP site over a period of 13 days. A total of 10.96 inches of rain was reported for the Mouth of Boulder Creek (BCMO) stream gage station over a period 16 days.

TABLE 7
Estimate of Equivalent ASM Sludge Production and Costs for Sludge Haulage
1998 Winter Season

Drying Bed	Start Date	Stop Date	Treatment Process	Volume Sludge (cubic yds)	209% Equivalent ASM Sludge (cubic yds)	244% Equivalent ASM Sludge (cubic yds)
1	01/01/97	01/05/97	ASM	5,080	5,080	5,080
1	08/01/97	02/10/98	HDS	13,200	27,500	32,100
4	02/10/98	03/21/98	HDS	16,300	33,900	39,600
2	03/21/98	07/24/98	HDS	18,100	37,700	44,100
HDS Total				**47,500**	**99,100**	**115,800**
Incremental sludge volume (cubic yards)					51,600	68,300
Incremental cost increase @ $22 per cubic yd					$ 1,134,500	$ 1,502,500
Incremental cost increase @ $35 per cubic yd					$ 1,804,900	$ 2,390,300

Cost data obtained from SMC (EPA, 1996) show that wet-winter sludge haulage is significantly more costly than haulage events taking place in dry conditions. The estimated cost for wet-winter haulage of ASM sludge ranges from $22 per cubic yard to $35 per cubic yard (SMC, 1998). The incremental cost for hauling ASM in 1998 would be approximately $1.134 million to $2.39 million to haul the additional ASM sludge in winter 1998 if the ASM process were in operation. Additionally, because of the superior handling properties of the HDS sludge, SMC reports that the sludge haulage costs for 1998 will be approximately $14.60 per cubic yard (EPA, 1998). This reduction in sludge haulage cost will result in additional savings of between $381,000 and $1,390,000.

The overall cost savings for 1998 of $1.5 million to $3.78 million does not take into account the increased difficulty and expense in placing ASM sludge in Brick Flat Pit. Because of the failures of the northeast ASM dump station and the west slope ASM dump station, a dump station was not available in Brick Flat Pit during winter 1998. The increase in cost resulting from this unavailability of a sludge dump station at Brick Flat Pit is not included in the cost estimate. Additional cost savings not included in this analysis are the savings resulting from refurbishing fewer sludge drying beds and savings associated with an increase in the long-term operational life of Brick Flat Pit with the HDS treatment process.

Works Cited

Stauffer Management Company (SMC). 1998 Iron Mountain Mine Brick Flat Pit Baseline Status Report. April 1998.

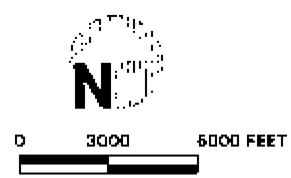
U.S. Environmental Protection Agency (EPA). 1996. Technical Memorandum from CH2M HILL to EPA. *Treatment Plant Sludge Evaluation, Dewatering Process Performance, Iron Mountain Mine*. Larry Well et al. November 20, 1996.

U.S. Environmental Protection Agency (EPA). 1998. Record of Communication, Lloyd Freese, SMC, to Rick Sugarek, EPA. September 24, 1998.

Appendix

NO.	LOCATION	ELEVATION
1	Upper Slickrock Creek	2890'
2	Upper Boulder Creek	2630'
3	Upper Spring Creek	1630'
4	Spring Creek Weir	1400'
5	Station 14	900'
6	Below Shasta Dam	600'
7	SCDD Outlet	600'
8	Below Keswick Dam	500'

Note: Elevations Approximated
From USGS Quad Sheets



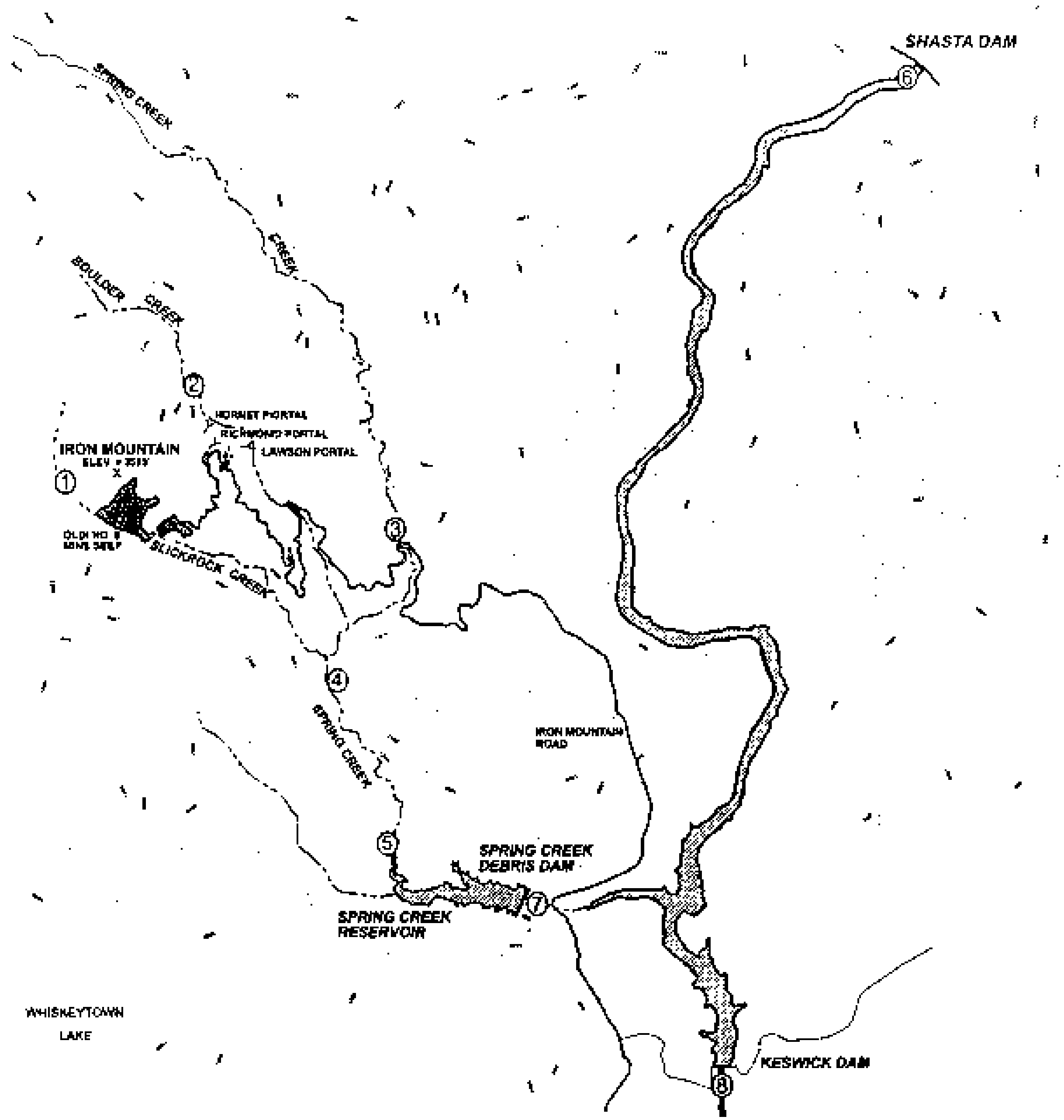
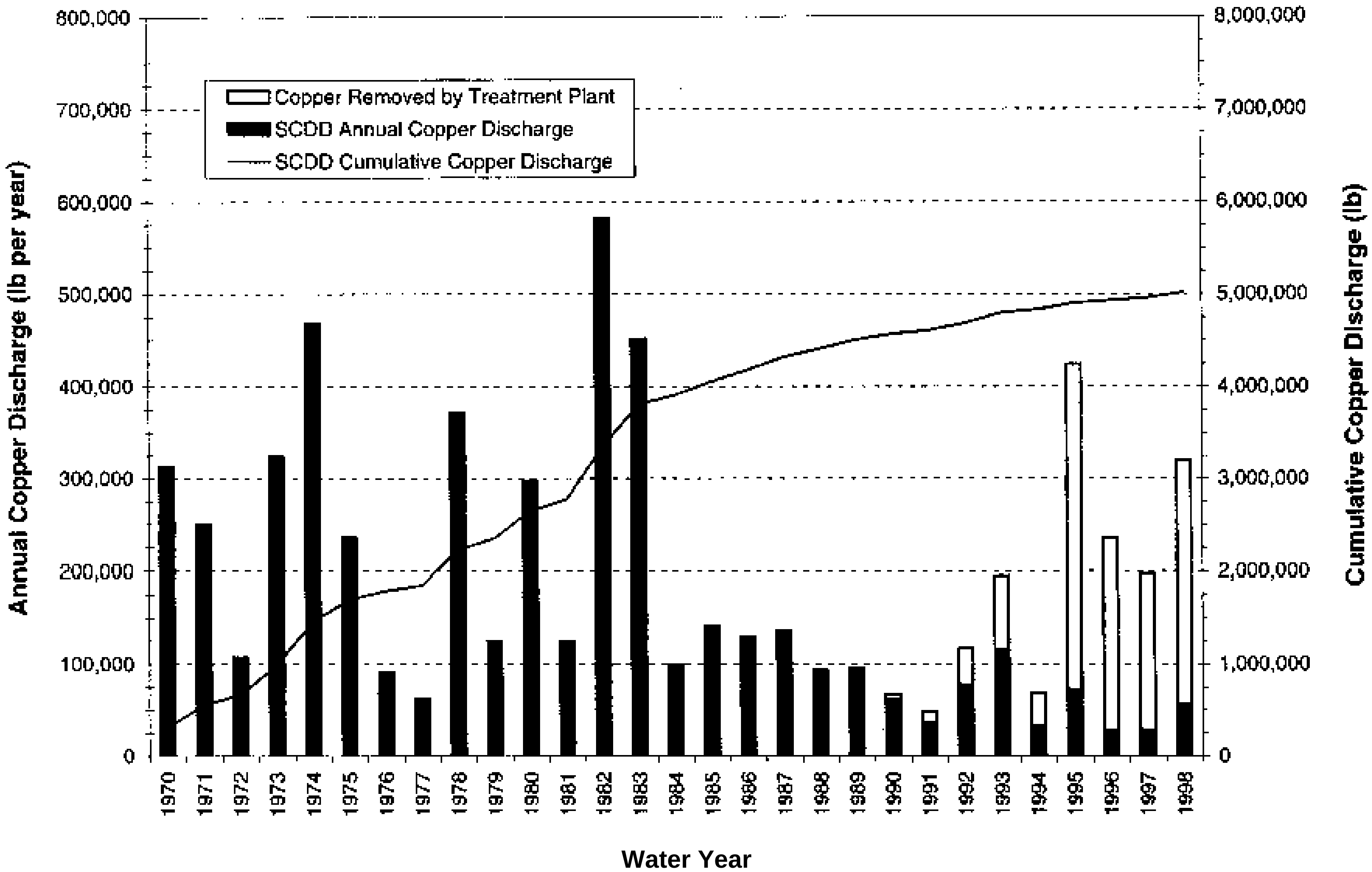


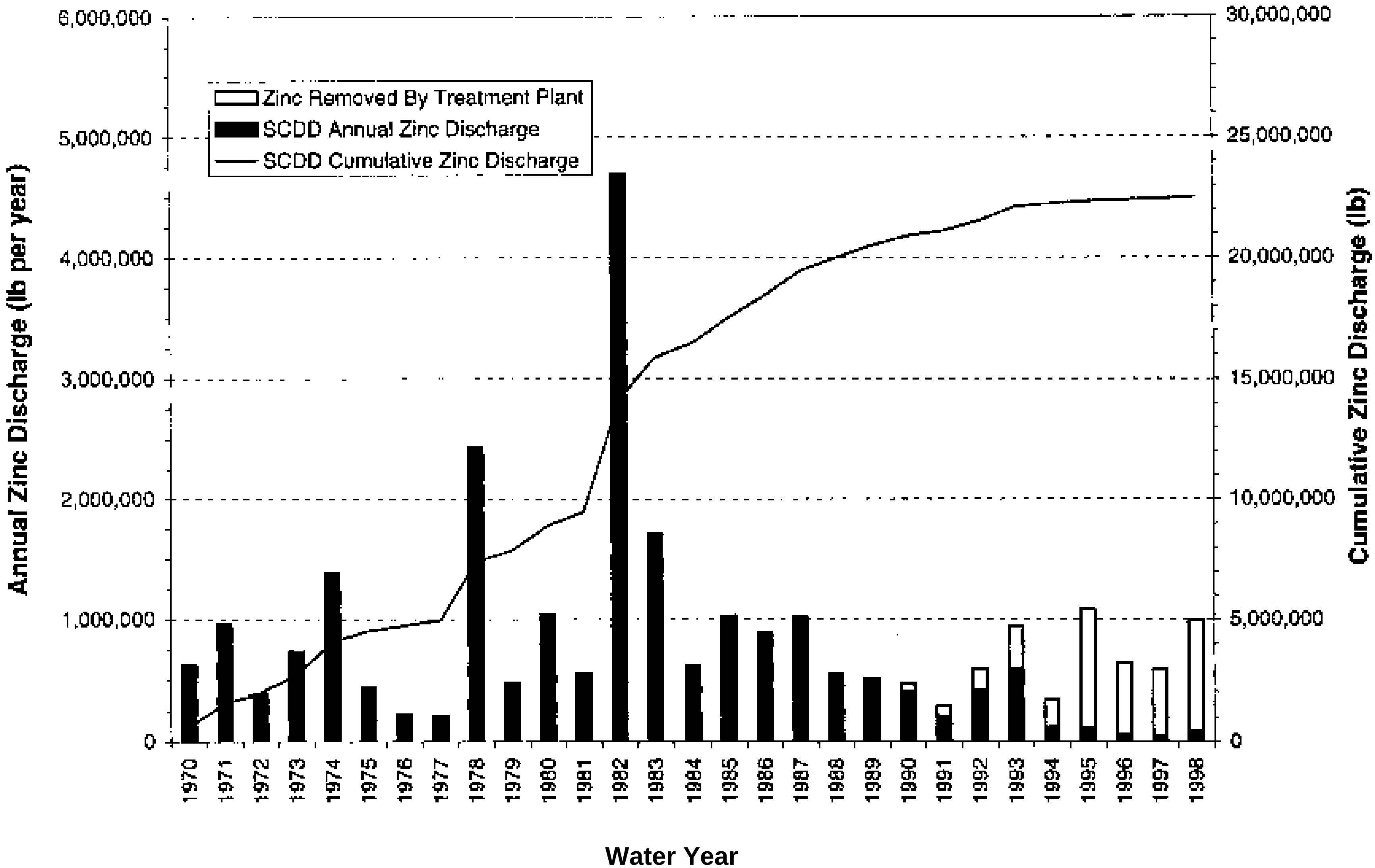
Figure 1
Location Map
Iron Mountain Mine



1994-1998: Copper Removed by Treatment Plant = 1,028,000 lb

Figure 2
Copper Discharge
Water Years 1970-1998
Iron Mountain Mine

Site 94-98.xls: Figure 2



1994-1998: Zinc Removed by Treatment Plant = 3,241,000 lb

Figure 3
Zinc Discharge
Water Years 1970-1998
Iron Mountain Mine

Table A-1
SCDD Copper and Zinc Discharge: 1970 -1998 Water years
Iron Mountain Mine

Water Year	SCDD Discharge (Acre-ft)	Annual Copper (lb)	Cumulative Copper (lb)	Annual Zinc (lb)	Cumulative Zinc (lb)
1970	39,248	313,471	313,471	620,080	620,080
1971	32,334	249,828	563,298	967,460	1,587,539
1972	10,236	107,645	670,943	377,701	1,965,241
1973	38,853	324,551	995,494	733,315	2,698,556
1974	62,806	468,516	1,464,010	1,386,576	4,085,133
1975	31,213	236,319	1,700,329	440,408	4,525,540
1976	7,495	91,300	1,791,629	225,771	4,751,311
1977	2,955	63,044	1,854,674	208,976	4,960,288
1978	57,180	371,769	2,226,443	2,437,129	7,397,417
1979	15,156	125,212	2,351,655	468,785	7,866,202
1980	32,820	297,479	2,649,133	1,045,093	8,911,295
1981	24,276	124,935	2,774,068	554,420	9,465,715
1982	52,290	582,541	3,356,609	4,695,683	14,161,398
1983	83,856	451,591	3,808,199	1,714,696	15,876,094
1984	29,441	99,875	3,908,075	619,616	16,495,710
1985	19,680	141,365	4,049,439	1,028,050	17,523,760
1986	38,364	129,532	4,178,971	892,608	18,416,368
1987	16,813	136,958	4,315,929	1,019,126	19,435,495
1988	16,964	93,301	4,409,230	544,878	19,980,372
1989	19,579	95,706	4,504,936	504,504	20,484,876
1990	13,709	61,750	4,566,687	401,006	20,885,882
1991	4,730	36,728	4,603,414	209,692	21,095,574
1992	14,671	77,884	4,681,298	406,776	21,502,350
1993	23,240	114,970	4,796,268	591,205	22,093,556
1994	4,191	32,739	4,829,006	118,666	22,212,222
1995	40,952	72,601	4,901,607	110,379	22,322,601
1996	18,669	28,170	4,929,777	52,568	22,375,169
1997	28,856	27,851	4,957,628	47,313	22,422,483
1998	74,989	55,993	5,013,621	78,674	22,501,157
Total	855,563	5,013,621		22,501,157	

Table A-2
Copper and Zinc Load Collected by IMM Treatment plant
Iron Mountain Mine

Water Year	Plant Inflow (gal)	Influent Copper (lb)	Influent Zinc (lb)
1970			
1971			
1972			
1973			
1974			
1975			
1976			
1977			
1978			
1979			
1980			
1981			
1982			
1983			
1984			
1985			
1986			
1987			
1988			
1989			
1990	4,352,979	5,849	64,682
1991	5,380,272	11,658	85,316
1992	10,467,006	38,920	176,265
1993	25,305,355	79,182	351,492
1994	22,098,293	36,302	226,877
1995	162,372,924	351,478	972,529
1996	108,883,298	206,954	585,914
1997	107,146,938	169,516	537,979
1998	192,784,060	264,375	917,420
Total	638,791,126	1,164,234	3,918,474

Table A-3
Total Iron Mountain Load: SCDD Discharge + Treatment Plant Load
Iron Mountain Mine

Water Year	SCDD Discharge (Acre-ft)	Annual Copper (lb)	Annual Zinc (lb)	Percent Water Year	Reduction Copper (%)	Zinc (%)
1970	39,248	313,471	620,080			
1971	32,334	249,828	967,460			
1972	10,236	107,645	377,701			
1973	38,853	324,551	733,315			
1974	62,806	468,516	1,386,576			
1975	31,213	236,319	440,408			
1976	7,495	91,300	225,771			
1977	2,955	63,044	208,976			
1978	57,180	371,769	2,437,129			
1979	15,156	125,212	468,785			
1980	32,820	297,479	1,045,093			
1981	24,276	124,935	554,420			
1982	52,290	582,541	4,695,683			
1983	83,856	451,591	1,714,696			
1984	29,441	99,875	619,616			
1985	19,680	141,365	1,028,050			
1986	38,364	129,532	892,608			
1987	16,813	136,958	1,019,126			
1988	16,964	93,301	544,878			
1989	19,579	95,706	504,504			
1990	13,709	67,600	465,688	1990	9%	14%
1991	4,730	48,385	295,008	1991	24%	29%
1992	14,671	116,804	583,041	1992	33%	30%
1993	23,240	194,152	942,698	1993	41%	37%
1994	4,191	69,040	345,543	1994	53%	66%
1995	40,952	424,078	1,082,908	1995	83%	90%
1996	18,669	235,124	638,483	1996	88%	92%
1997	28,856	197,367	585,292	1997	86%	92%
1998	74,989	320,368	996,094	1998	83%	92%
Total	855,563	6,177,855	26,419,631			